SQUID amplifiers for Infrared Detectors and Other Applications

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The advantages of superconducting processing circuitry for focal plane arrays include low power consumption and the possibility of integrating processing circuitry and detectors on the same substrate. The latter configuration allows for reduction in the number of leads to the readout system and therefore removes a significant bottle neck to processing the massive quantities of data coming from large IR FPAs. All signal processing steps may be executed with superconducting circuit elements. Amplification in superconducting circuitry is performed with the SQUID (Superconducting Quantum Interference Device) amplifier. The present phase I SBIR is being used to investigate a scheme for multiplexing many inputs into one SQUID amplifier. This will reduce the number of SQUID amplifiers needed which is a significant improvement because typical high-gain, multiturn-input SQUIDs are the largest element of superconducting circuitry.

The basic unit of the multiplexing scheme is the parametric flux transformer shown in Fig. 1. The transformer has three coils in series with a single Josephson junction. The "signal in" is injected into one of the transformer inputs and the "signal out" is obtained at another of the transformer inputs. A third transformer input "control" varies the gain between signal input and output. It is the presence of the Josephson junction in the loop which produces a non-linear relationship between the inputs allowing the control of gain. Note that the loop with the Josephson junction is formally equivalent to an rf SQUID, however conventional rf SQUIDs have one, not three, input coils, and are not used in this configuration or with the purpose intended here. One of the most important results obtained from calculations done so far is that it is possible to change the gain from zero to infinity in the small signal limit by adjusting the control input. This result is very important because the ability to set the gain to zero allows multiplexing by permitting all signals but one to be pinched off. For finite signals, the range of possible gains depends on the precise amplitude of the input. Figure 2 shows the configuration of a system that multiplexes three inputs into one SQUID using the parametric transformer concept. Note that the three elements can be devices in series (such as Josephson junction infrared detectors) but that the noise detected in the SQUID comes from only one of the devices in the series. Thus the noise does not add.

The anticipated payoff of this research is in shrinking the size needed for superconducting circuitry that will be integrated onto IR FPA's. In addition, this method should add very little or no noise to the intrinsic detector noise, thus avoiding any degradation in sensitivity when individual detectors are integrated into the array.

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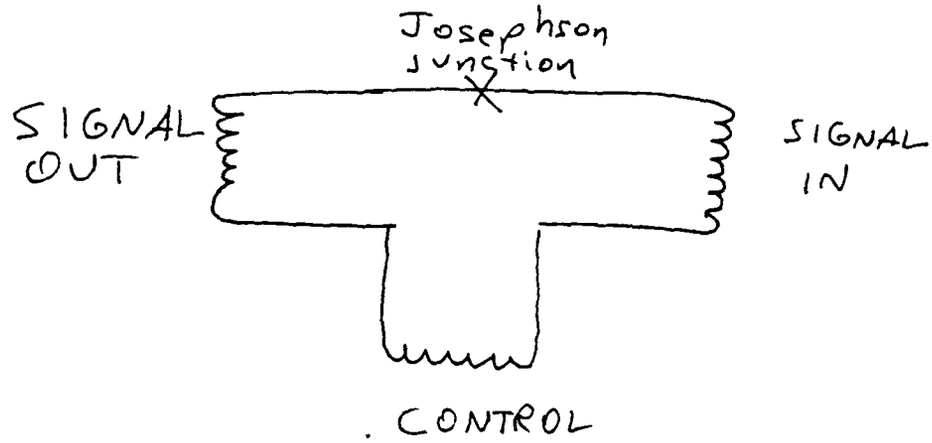

Parametric flux transformer

FIG 1

Statement "A" per telecon Fred Quelle.
Office of Naval Research Detachment,
Boston. 495 Summer St. Boston, MA
02210-2109.
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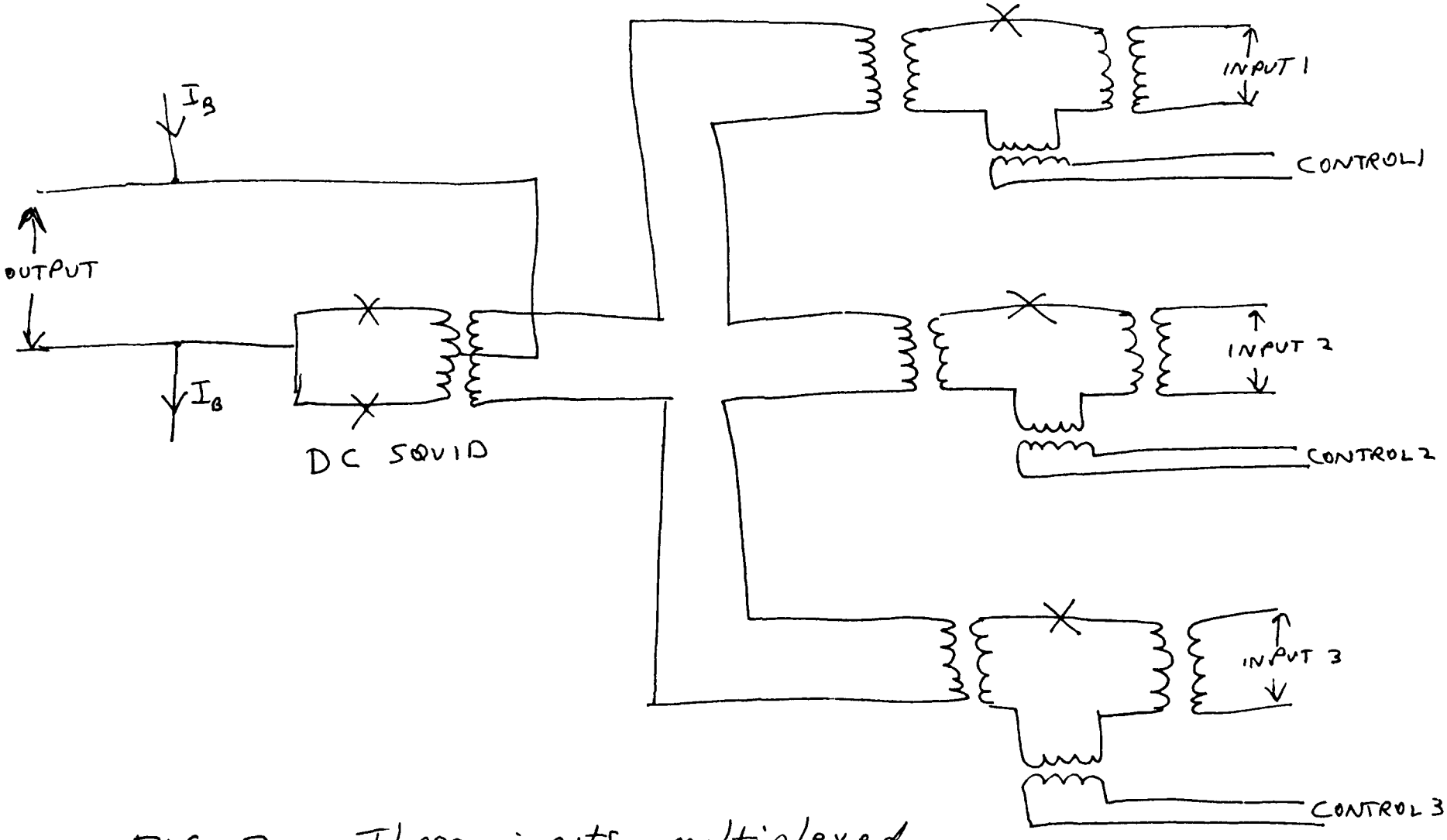

FIG 2 - Three inputs multiplexed into a single DC SQUID amplifier